DEPOE BAY SEDIMENT QUALITY STUDY

7 April 1980

1. Depoe Bay is situated on the Oregon Coast approximately 100 miles south of the mouth of Columbia River (figure 1). The bay consists of a shallow indentation in the shoreline and adjoins an almost landlocked inner bay. The inner bay is fed by a small stream, Depoe Creek, which is dammed a few hundred feet above its confluence with the bay. This creek has a low flow. As a result, currents and water quality within the inner bay are dominated by ocean surges and tides.

2. The access channel to the inner bay is 50 feet in width. A 390-by-750-foot boat basin is located within this bay. Both the boat basin and channel are federally authorized for an 8-foot depth which is maintained by the U.S. Army Corps of Engineers.

3. Since 1950, a total of 63,100 cubic yards of sediments have been removed from the harbor by the Corps. Of that total, 19,100 cubic yards have been discharged into upland disposal sites and 44,000 cubic yards have been disposed at an ocean disposal site, which is located on the rocky, intertidal shoreline of the outer bay, approximately 200 feet south of the harbor entrance.

4. The harbor is scheduled for maintenance dredging in 1981. It is proposed that sediments removed at that time be placed at the ocean disposal site. This site is precipitous and violently wave washed. As a result, little foot traffic takes place on it. A detailed discussion of the flora and fauna of the site and impacts to them from past disposal activities is available in the Corps' publication, "Intertidal Disposal of Dredged Materials at Depoe Bay, Oregon."[1]

5. Disposal of dredged material at ocean disposal sites is regulated by Section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA). Final revisions of the regulations and criteria governing this type

of ocean dumping were published in the 11 January 1977 issue of the Federal Register. The primary intent of Section 103 is to regulate and limit the environmental impact of ocean discharging. Using chemical, physical, and biological information obtained pursuant to the regulations, disposal sites are designated by the Corps and approved by the EPA upon submission of adequate baseline information by the Corps. The Corps bears primary responsibility in obtaining the data which is needed in making site designations or determining impacts.

6. In March 1980, the EPA, Region X, indicated via letter (attachment 1) that they were concerned that sediments to be dredged might be contaminated and that toxic and bioaccumulative effects of sediments upon discharge at the disposal site could be significant. They were also curious as to the source of any contaminants that might be present in the sediments.

7. Pursuant to their request for data, water and sediment sampling for elutriate analysis were performed by Corps personnel on 7 April 1980 (see figure 1 for sampling locations). Three sediment samples were obtained in the authorized project area (stations 1, 2, and 3). A fourth was obtained halfway from the Depoe Creek dam to the boat basin (station 4), and a fifth station was sampled immediately upstream of the Depoe Creek dam (station 5). Attachment 2 contains a description of the sampling methodology used at each of these locations.

8. A receiving water sample was obtained from the south side of the entrance channel, within 200 feet of the proposed disposal site, for comparative purposes (station 6). Sufficient sediment was obtained at station 1 (southern boat basin) to provide for a bulk sediment analysis as well as an elutriate test. This station was chosen over the other two in the boat basin because field inspection of sediments indicated that those from station 1 were the poorest in quality in the proposed dredging area. Subsequent analysis bore out this supposition.

9. A consultant firm performed five elutriate tests, one receiving (ocean) water analysis, and one bulk sediment chemical analysis on the samples provided

(attachment 3 contains results). In addition, the Corps' Division Materials Laboratory performed physical analyses on three of these sediment samples and on a fourth sample obtained from immediately below the Depoe Creek dam (station 7) (Attachment 4). The data provided by the two laboratories is discussed below.

DISCUSSION

10. Chemical Data. Of the 27 parameters for which the elutriate samples were analyzed, only four were present at levels exceeding applicable water quality criteria as promulgated in the EPA publication, "Quality Criteria for Water."[2] These were manganese, ammonia, phenols, and iron. The last was found at excessive levels only in samples from stations located in the dam apron and upstream of the dam and, therefore, is not of particular concern in terms of dredged material disposal impacts.

11. The remaining three parameters, ammonia, manganese, and phenol, are generally recognized as being readily released from sediments during elutriate testing.[3] Fortunately, they are not of concern in terms of toxic or bioaccumulative effects at the levels detected during this study. Also, manganese was not detected at excessive levels during the bulk sediment analysis.

12. It is expected that the comparatively high levels of both manganese and ammonia in the elutriate samples were due to their tendency to elutriate under anaerobic conditions (such as occur during elutriate sample preparation) rather than the presence of excessive levels of them in the sediments. Neither parameter is expected to exert a long-term impact on water quality at the disposal site.[3]

13. In addition to the four parameters discussed above, zinc was detected at levels considerably in excess of those found in the receiving water sample. However, the bulk sediment analysis of the station 1 sediment sample indicated that the level present was at the low end of the moderately polluted range

(09-200 mg/1).[4] The impact of disposal of such low levels of zinc are expected to be insignificant because the element's toxicity is inversely related to the level of oxygen in the water and the surf water will be saturated with oxygen. Also, zinc is not of particular concern in reference to bioaccumulative effects at levels which are nontoxic.

14. Arsenic was also elutriated from boat basin sediments at levels higher than from sediments from near the dam. However, the levels detected did not exceed EPA water quality criteria. Arsenic in sediment is not of as much concern as dissolved arsenic because the latter is commonly present in its trivalent inorganic form which is converted to the pentavalent form in bottom sediments. The former is from 10 to 15 times more toxic than the latter and should be safe for typical benthic organisms at levels as high as 1,920 mg/kg.[2] The level found in the station 1 sediments was 13.2 mg/kg.

15. Overall, the sediments at stations 4 and 5 (downstream and upstream of the dam, respectively) contained higher levels of the parameters measured than did the samples obtained in the boat basin. Also, of the three samples obtained in the boat basin, the one from the transect nearest the creek was the poorest in quality.

16. Physical Data. Sediment in the apron below the dam had a large portion of rubble mixed through it. This rubble was largely omitted from the samples which underwent grain size analysis.

17. In the area closest to the dam, the predominant sediment type was sand and rubble. The lower portion of the apron was characterized by a mixture of sand, clay, silt, and rubble scattered in relatively distinct pockets. The east bank of the apron was being strongly eroded and the clay fraction may have originated from that area as well as from Depoe Creek.

18. The sediment from station 5 (upstream of the dam) was a brown-black, silty sand mixed with a high percentage of organic material of apparently detrital origin (16.35 percent). The presence of the latter was not surprising as the sampling location was in a small wetland where vegetation grew in profusion.

19. The sediment obtained from station 2 in the boat basin was more similar in appearance and grain size to that which was sampled above the dam than to that which came from the dam apron. It consisted of fine sand with a high percentage of organic material (9.51 percent), though not nearly as much as station 5.

20. The Mayor of Depoe Bay told the sampling crew that the lower spillway of the dam released large quantities of sediments such as were found in the wetland when it was opened. It appears likely that this material made its way to the boat basin where it settled. Boat basin sediments from near the access channel appeared to have a higher sand content than the others and was of a lighter color.

CONCLUSION

21. Sediment from immediately upstream of the Depoe Creek dam contained a higher percentage of the parameters measured than did any of the other sediments which were tested. Since this sediment is being released in significant quantities from the dam, it is expected that it is the major source of contaminants in the sediments to be dredged.

22. The sediments generally improve in quality the closer they are to the harbor's entrance channel. Elutriation and subsequent removal of contaminants by the ocean currents is probably responsible for the improvement.

23. The grain size analysis of the sample from the middle of the boat basin indicated that the sediments were composed of near 80 percent fine sand. This type of material has been quickly removed from the disposal site upon discharge in the past and, given the strong wave action and undertow in the outer embayment, the majority is expected to move beyond the reefs which extend from the arms of the bay.

24. Because of the outer bay's extreme hydrographic regime for the majority of the year and the lack of adequate bathymetry data outside the channel area

no sampling should be attempted. Significant reasons to believe there is a sediment buildup must be shown before a field crew is risked in the outer bay.

LITERATURE REFERENCE LIST

1. U.S. Army Corps of Engineers. "Intertidal Disposal of Dredged Materials at Depoe Bay, Oregon," U.S. Army Engineer District Portland, October 1978.

2. U.S. Environmental Protection Agency. "Quality Criteria for Water," USEPA 440/9-76-023, Washington, D.C., 1976.

3. Environmental Effects Laboratory. "Long-term Release of Contaminants from Dredged Material," Technical Report D-78-49, U.S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Mississippi, August 1978.

4. U.S. Environmental Protection Agency. "Guidelines for the Pollutional Classification of Great Lakes Harbor Sediments," USEPA, Region V, Chicago, Illinois, April 1977.

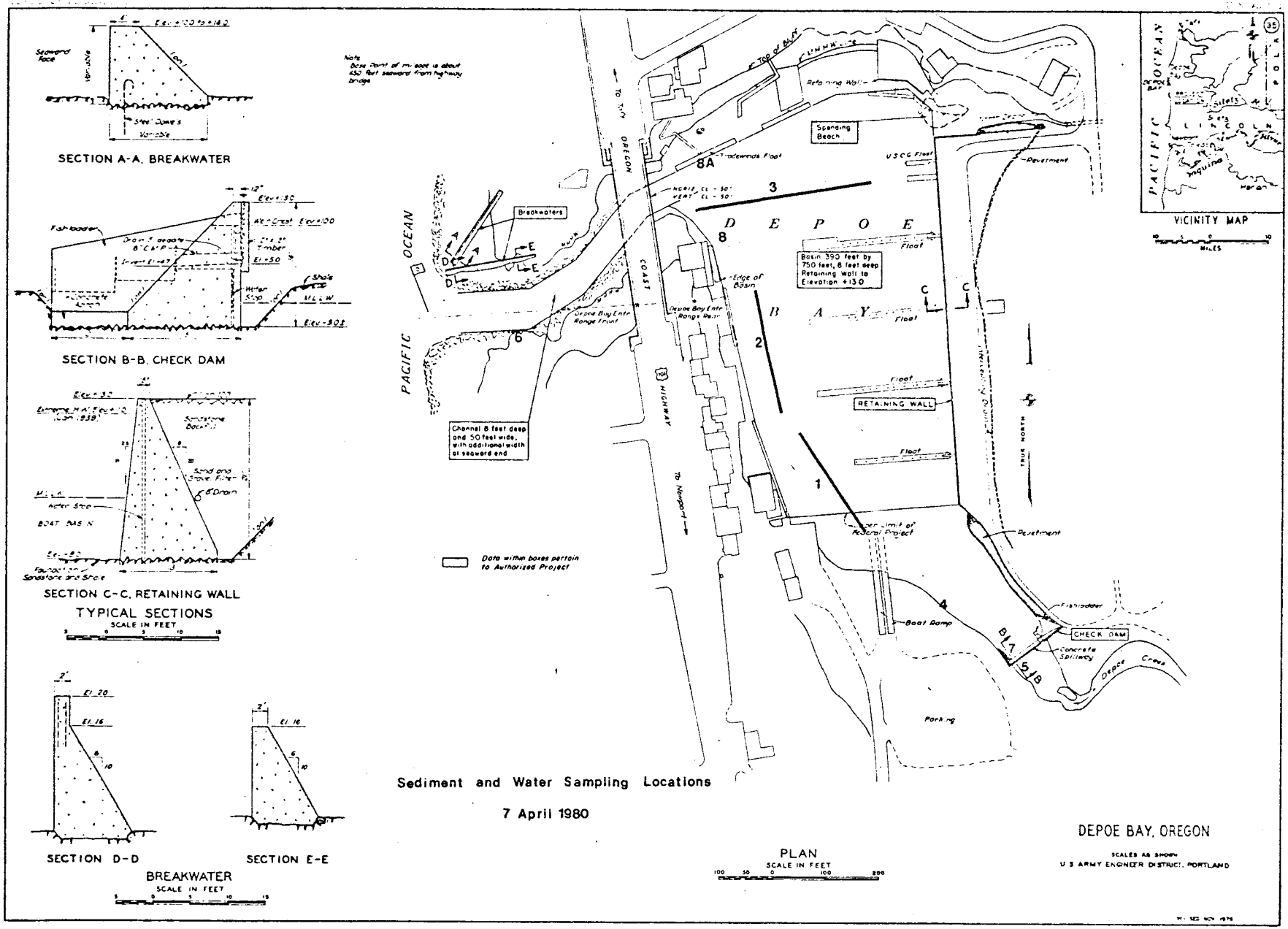
SECTION A-A. BREAKWATER
SECTION B-B. CHECK DAM
SECTION C-C. RETAINING WALL
TYPICAL SECTIONS
SCALE IN FEET
SECTION D-D
SECTION E-E
BREAKWATER
SCALE IN FEET
Sediment and Water Sampling Locations
7 April 1980
PLAN
SCALE IN FEET
DEPOE BAY, OREGON
SCALES AS SHOWN
U S ARMY ENGINEER DISTRICT, PORTLAND
VICINITY MAP
PACIFIC OCEAN
DEPOE
BAY
RETAINING WALL
CHECK DAM
Boat Ramp
Parking
Breakwaters
Spouting Beach
Pavement
Float
Channel 8 feet deep and 50 feet wide, with additional width at seaward end
Basin 390 feet by 750 feet, 8 feet deep
Retaining wall to Elevation +13.0
Data within boxes pertain to Authorized Project
TRUE NORTH

Figure 1

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION X
1200 SIXTH AVENUE
SEATTLE, WASHINGTON 98101

REPLY TO ATTN OF: MS 521

MAR 21 1980

Mr. A. J. Heineman
Chief, Navigation Division
Portland District, C/E
P. O. Box 2946
Portland, Oregon 97208

RE: NPPND-079, Corps of Engineers, January 16, 1980

Dear Mr. Heineman:

We have reviewed the above referenced project for maintenance dredging of Depoe Bay and the U. S. Army Engineer report "Intertidal Disposal of Dredged Materials at Depoe Bay, Oregon" (October 1978). The U. S. Army Engineer report makes several references to the possible toxic effects of the materials that are deposited within the intertidal disposal site but never properly evaluates these effects. Instead of dealing with the possible effects the report recommends the continued use of the intertidal disposal area on the grounds that it "appears to be environmentally acceptable and economically justified".

It is the opinion of this agency that a statement of the environmental acceptability and economic justification of the use of an intertidal disposal site should be withheld until the possible toxic effects of the material to be disposed of can be properly evaluated. Such an evaluation should address two basic questions. First, are the observed contaminants from a natural source or are they a result of activities associated with the Depoe Bay boat basin? Second, are the contaminants that are deposited with the dredge material in the intertidal disposal site collecting in subtidal areas within the outer embayment?

A study designed to answer these questions should include the following:

1. Sediment samples should be taken from Depoe Creek and along a transect from the dam at Depoe Creek to the northern shore of the boat basin. An elutriate test should be used to determine the concentrations of lead, zinc, copper, cadmium, arsenic, and

Attachment 1

mercury. If results indicate that these contaminants originate in Depoe Creek or from some other natural source no further sampling will be necessary. If these contaminants appear to originate from the boat basin the study described below should be conducted.

2. Sediment samples should be taken from the outer embayment which is being used for the disposal of dredged material. This study should include the subtidal areas between the northern and southern shores and between the eastern shore and the proximity of the reef forming the western extent of the embayment. Sampling should be conducted along east-west transects and should include any trenches, large crevices and other areas that could collect sediments. An elutriate test should be used to determine the concentrations of lead, zinc, copper, cadmium, arsenic and mercury at each sample site. The results of these tests should be evaluated to determine if contaminants are collecting within the outer embayment. If contaminants are collecting within the embayment further tests to evaluate the possibility of bioaccumulation of the materials may be necessary.

We would like to emphasize that our concern is with the possible toxic effects of the materials being deposited in an intertidal area and the possible accumulation of these materials within a semi-enclosed embayment. We recognize and appreciate the need for dredging the Depoe Bay boat basin, but we suggest that alternate disposal sites be used until proper evaluation of the environmental effects of the intertidal disposal of the dredged material is completed.

Jim Wood of my staff is available at (206) 442-1352 to discuss this project with the Corps of Engineers at their convenience.

Sincerely,

Harold Geren

Harold Geren, Chief
Permits Section

cc: USFWS - Portland
NMFS
ODSL
ODFW
ODEQ
Port of Depoe Bay

FIELD REPORT

Depoe Bay

Purpose of Sampling. Section 103- At request of EPA - Jim Woods

Date 4/7/80 Wind Variable within harbor

Water Conditions (Wave heights & Direction, Tides, Currents) Surges from ocean waves

Weather Foul! It drizzled/rained all day Sampling Vessel Used Coast Guard Zodiac & regular vessel

Sampling Personnel Bob Ellard, Pam Moore, Ken Sepenel Sampling Gear Ponar, Ellard, & handdriven core

Analytical Laboratory CH_2M Hill

Comments (Wildlife, Sampling Difficulties, etc.) Too rocky to sample easily, needed more time, Did not have a chance or time to use hydrolab.

Station	Depth	Sampling Time	Sampling Methodology	Sampling Description
1	9'	2:00	Ellard from Coast Guard vessel	Dragged on north/south transect at southernmost end of boat basin. Did 3 drags to get enough sediment. Black silty material.
2	10'	2:15	Ellard from Coast Guard vessel	Dragged on north/south transect in middle section of boat basin. Black, silty sediment Had piece of old cloth in it (which was disgarded. Did one drag & got large amounts of material.
3	6'	1:45	Ellard from Coast Guard vessel	Dragged on east/west transect in northernmost part of boat basin. Sand & clay. Did 3 drags to get enough sediment. Had nematode in it.
4	4' of sediment 1" of water	11:30	Handsampled using a plastic core. Drove same corner repeatedly into a one square foot area.	Gray clay - Many rocks on surface & through clay made sampling difficult. One full core & ¼ a gallon jar were taken (labled 1 of 2 and 2 of 2) - was ordorless. Was located ½ of

Conclusions (Is sampling completed? Was sampling method adequate? Considerations for future sampling at the project) Sediments varied widely in quality in different areas. Sediments immediately below dam were too rocky to sample as were some areas in the boat basin. Sediments appeared to be contaminated by oil.

FIELD REPORT

Depoe Bay

Purpose of Sampling Section 103

Date 4/7/80 Wind

Water Conditions (Wave heights & Direction, Tides, Currents)

Weather Sampling Vessel

Sampling Personnel Sampling Gear

Analytical Laboratory

Comments (Wildlife, Sampling Difficulties, etc.)

Station	Depth	Sampling Time	Sampling Methodology	Sampling Description
				of distance from dam to harbor on west bank
				of Low Tide.
5	2" of	11:30	Ponar	Immediately upstream of dam sampled from
	water			SW side of dam. Brown-black mud. High
				organic content. Single sample.
6 Reg water		3:00	Used bucket from shore.	On south, oceanward side of channel. Some
			Caught surf.	detrital material from brown plants in
				intertidal area.
7	½" of	11:35	Handsampled	Sand & rocks - was obtained from below dam
	sediment			at low tide. To be used for grainsize
	1" of			
	water			
8	6'	1:00	Ponar from Zodiac	Dropped ponar 3 times to get sample but did not
				get enough to use for chemical analysis. South
				Side of harbor mouth.

Conclusions (Is sampling completed? Was sampling method adequate? Considerations for future sampling at the project)

~~Needed more time to adequately sample.~~ Also needed a small boat which could be equipped with handwinch and a boat which could sample receiving water. The coast guard wouldn't take us into the ocean that day because of surf action.

FIELD REPORT

Depoe Bay

Purpose of Sampling Section 103

Date 4/7/80 Wind

Water Conditions (Wave heights & Direction, Tides, Currents)

Weather Sampling Vessel

Sampling Personnel Sampling Gear

Analytical Laboratory

Comments (Wildlife, Sampling Difficulties, etc.)

Station	Depth	Sampling Time	Sampling Methodology	Sampling Description
8A			Ponar with Zodiac	Also tried to sample with ponar on north side of mouth of boat basin but was too rocky.

Conclusions (Is sampling completed? Was sampling method adequate? Considerations for future sampling at the project)

Table 1
DEPOE BAY
Elutriate Test Results
7 April 1980

Parameter	Analytical Methods[1]	1	2	3	4	5	6	Water Quality Criteria[2]
Iron, Fe, µg/l	A 236.1	820	200	200	1,550	118,000	300	1000*
Manganese, Mn, µg/l	A 243.1	190	190	320	1,400	1,880	40	100
Lead, Pb, µg/l	B 151-152	<5	<5	<5	<5	<5	<5	100
Mercury, Hg, µg/l	A 245.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	.1
Nickel, Ni, µg/l	A 249.1	<10	10	<10	<10	80	<10	100
Copper, Cu, µg/l	A 220.1	50	50	50	50	50	50	---
Zinc, Zn, µg/l	A 289.1	90	20	32	310	67	<5	---
Cadmium, Cd, µg/l	B 151-152	<5	<5	<5	<5	<5	<5	5.0
Barium, Ba, µg/l	A 208.1	<1,000	<1,000	<1,000	<1,000	<1,000	<1,000	50,000
Chromium, Cr, µg/l	A 218.1	<50	<50	<50	<50	<50	160	100
Cyanide, CN, µg/l	B 370-372	<5	<5	<5	<5	<5	<5	5.0
Arsenic, As, µg/l	A 206.2	6	2	6	<2	<2	<2	50.0
Beryllium, Be, µg/l	A 210.1	<10	<10	<10	<10	<10	<10	11
Total Kjeldahl Nitrogen, N, mg/l	A 351.4	1.64	1.51	1.21	2.62	4.07	0.13	---
Ammonia, N, mg/l	A 350.3	1.40	0.96	0.61	2.29	3.69	0.05	1.1*
Total Phosphate, P, mg/l	B 476, 481-482	0.03	0.05	0.07	<0.02	0.09	0.03	.1
Orthophosphate, P, mg/l	B 481-482	<0.02	0.04	0.06	<0.02	<0.02	<0.02	---
Phenols, µg/l	A 420.1	75	68	83	331	95	48	1.0

Attachment 3

Table 1 (continued)
DEPOE BAY
Elutriate Test Results
7 April 1980

Parameter	Analytical Methods[1]	1	2	3	4	5	6	Water Quality Criteria[2]
Organochlorine Insecticides, µg/l	C							
Aldrin		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
Dieldrin		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
DDT		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	
Endrin		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	
Toxaphene		<1	<1	<1	<1	<1	<1	
Chlorophenoxy Herbicides, µg/l	C							
2, 4-D		<1	<1	<1	<1	<1	<1	
Silvex		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	
Sulfides, mg/l	B 503-505	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	.002
Total Organic Carbon, mg/l	A 415.1	1.4	0.9	0.7	3.5	0.5[3]	0.7	

< Indicates "less than"
[1]See Key
[2]Obtained from USEPA, "Qualilty Criteria for Water," U.S. Environmental Protection Agency, Washington, DC (July 1976).
[3]Results are suspected to be low due to sulfur interference.

Sample Designations
1 South Basin
2 Middle Basin
3 North Basin
4 Core Sample, Downstream from Dam
5 Upstream from Dam
6 Site Water

* - Criteria for freshwater only.

mn/2823

TABLE 2
DEPOE BAY, STATION 1
Bulk Sediment Analysis
7 April 1980

Parameter	Analytical Methods[1]	Dry Weight	Wet Weight	Guidelines for Non-Polluted Sediments (Dry Weight) (4)
Iron, Fe, mg/Kg	A 236.1	20,980	7,760	17,000
Manganese, Mn, mg/Kg	A 243.1	138	51.0	300
Lead, Pb, mg/Kg	B 151-152	9.45	3.50	40
Mercury, mg/Kg	A 245.5	0.291	0.108	1.0
Nickel, Ni, mg/Kg	A 249.1	26.1	9.65	20
Copper, Cu, mg/Kg	A 220.1	34.4	12.7	25
Zinc, Zn, mg/Kg	A 289.1	111	40.9	90
Cadmium, Cd, mg/Kg	B 151-152	<1	<0.4	6
Barium, Ba, mg/Kg	A 208.1	<20	<7	20
Chromium, Cr, mg/Kg	A 218.1	28.0	10.4	25
Cyanide, CN, mg/Kg	B 370-372	<0.095	<0.035	.10
Arsenic, As, mg/Kg	A 206.2	13.2	4.90	*
Beryllium, Be, mg/Kg	A 210.1	<0.19	<0.07	--
Total Kjeldahl Nitrogen, N, mg/Kg	A 351.4	23,300	8,600	1,000
Total Phosphate, mg/Kg	B 476, 481-482	3,310	1,220	420
Phenols, mg/Kg	A 420.1	4.69	1.74	--

TABLE 2 - continued

DEPOE BAY, STATION 1

Bulk Sediment Analysis
7 April 1980

Parameter	Analytical Methods[1]	Wet Weight	Dry Weight
Organochlorine Insecticides, mg/Kg	C		
Aldrin		<0.003	<0.009
Dieldrin		<0.003	<0.009
DDT		<0.003	<0.009
Endrin		<0.003	<0.009
Toxaphene		<0.032	<0.085
Chlorophenoxy Herbicides, mg/Kg	C		
2, 4-D		<0.002	<0.005
Silvex		<0.0002	<0.0005
Sulfides, mg/Kg	B 505-506	585	1,580
Total Organic Carbon, mg/Kg	A 415.1	2.3%	6.2%

< Indicates "less than"
[1]See Key

mn/2823

* - Highly toxic trivalent inorganic arsenic is converted to pentavalent arsenic in bottom sediments. The latter is from 10 to 15 times less toxic than the former and should be safe for typical benthic organisms at levels as high as 1,920 mg/kg. (Lueschow, L.A.; 1964)

TABLE 3
DEPOE BAY
Sediment Analysis
7 April 1980

Metal	Detection Limit, µg/l	± Error	% Recovery of Spikes
Iron, Fe	50	50	85
Manganese, Mn	10	10	100
Lead, Pb	5	5	105
Mercury, Hg	0.5	0.5	95
Nickel, Ni	10	10	110
Copper, Cu	10	10	108
Zinc, Zn	5	5	100
Cadmium, Cd	5	5	100
Barium, Ba	1,000	1,000	
Chromium, Cr	50	50	100
Arsenic, As	2	2	88
Beryllium, Be	10	10	100

Notes:
1. High background reduced detection limits for Ba and Be.
2. Spike for Barium was below detection limit.
3. A chelation extraction was used for Cd and Pb due to low recovery of spike using furnace technique.
4. Mercury was determined using cold vapor.
5. Replicates were 1 in 5 or better for each metal.

Other Chemical	Detection Limit		± Error
Cyanide, CN, µg/l	5		5
Nitrogen, as mg/l N			
Total Kjeldahl	0.02		0.02
Ammonia	0.02		0.02
Phosphates, as mg/l P			
Total	0.02		0.02
Ortho	0.02		0.02
Sulfides, as mg/l S	0.01	(water)	0.01
	0.1	(sediment)	0.1
Phenols, µg/l	2		2
Total Organic Carbon	0.1		0.1

Notes:
1. An EPA reference sample for CN was analyzed with 93 percent recovery.
2. Replicates were 1 in 5 for nitrogens, phosphates, and sulfides. No replicates were run on the others.
3. No spikes were analyzed.

Table 3 (continued)

Other Chemical	Detection Limit Liquid	± Error
Organochlorine Insecticides, µg/l		
Aldrin	0.2	0.2
Dieldrin	0.2	0.2
DDT	0.2	0.2
Endrin	0.1	0.1
Toxaphene	1	1
Chlorophenoxy Herbicides, µg/l		
2, 4-D	1	1
Silvex	0.1	0.1

Notes: 1. Detection limits for sediment are higher due to smaller extracted sample weight.

mn/2823

TABLE 4
DEPOE BAY
Sediment Analysis
7 April 1980

Sample	Solid/Liquid Ratios (Vol/Vol mls)
South Basin	2,800/630
Middle Basin	1,350/2,220
North Basin	2,240/1,200
Upstream from Dam	2,670/690

Sample	% Moisture of Sediment Samples (as analyzed)
South Basin	63.0
Middle Basin	47.1
North Basin	29.2
Core Sample Downstream from Dam	30.2
Upstream from Dam	65.7

Analytical Methods

A. U.S. Environmental Protection Agency, "Methods for Chemical Analysis or Water and Wastes," 1979.

B. American Public Health Association, "Standard Methods for the Examination of Water and Wastewater," 14th Ed., American Water Works Association, Water Pollution Control Federation, APHA, New York, 1975.

C. U.S. Environmental Protection Agency, "Pesticides and Herbicides in Water," EPA Binder, 1976.

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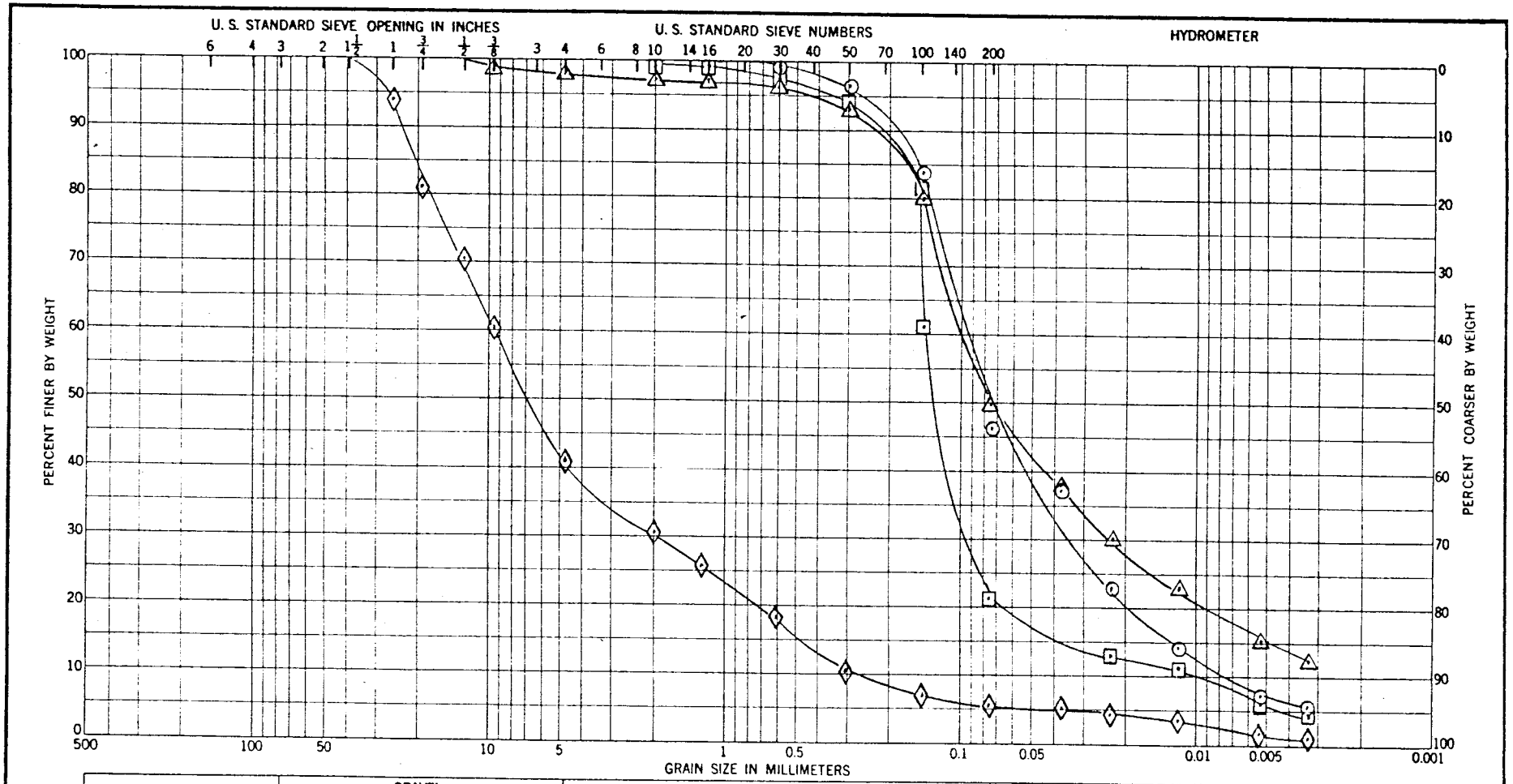


Sample No.	[illegible]	Classification	Nat w %	LL	PL	PI
⊙ Station	5	Organic Silty SAND (SM)				
△ Station	4	Organic Silty SAND (SM)				
⊡ Station	2	Organic Silty SAND (SM)				
◇ Station	7	Silty Sand GRAVEL (GW-GM)				

Samples obtained on 7 April 1980

GRADATION CURVES

NPD

Project DEPOE BAY

Area

Boring No.

Date 16 May 80

80-S-649

ENG FORM 1 MAY 63 2087

NPDEN-GS-L (80-S-649)

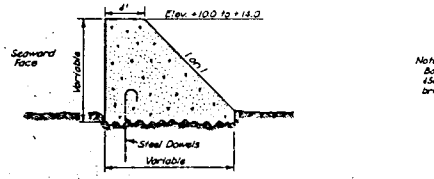
DEPOE BAY

16 May 1980

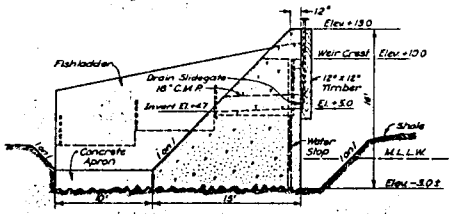
Sample No.	Date Sampled	Specific Gravity of Wtr	Density of Matl in place gms/liter	Density of Median Solids gms/liter	Void Ratio	% Organic Material	Roundness Grade
Upstream Dam West Bank	7 Apr 80	1.001	1447	2450	4.365	16.35	Angular to Subangular
Lower Dam Apron West Bank	7 Apr 80	1.001	1594	2660	1.805	5.71	Angular to Subangular
Middle Boat Basin	7 Apr 80	1.005	1381	2581	3.196	9.51	Angular to Subangular
Dam Apron Depoe Creek	7 Apr 80	1.001	2064	2706	0.604	2.00	Subangular to Subrounded

CORPS OF ENGINEERS

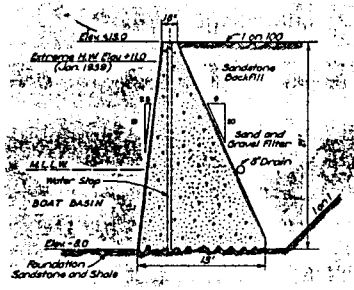
U.S. ARMY



SECTION A-A, BREAKWATER



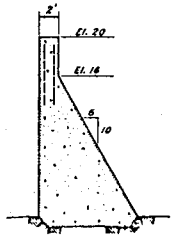
SECTION B-B, CHECK DAM



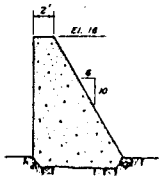
SECTION C-C, RETAINING WALL

TYPICAL SECTIONS

SCALE IN FEET



SECTION D-D

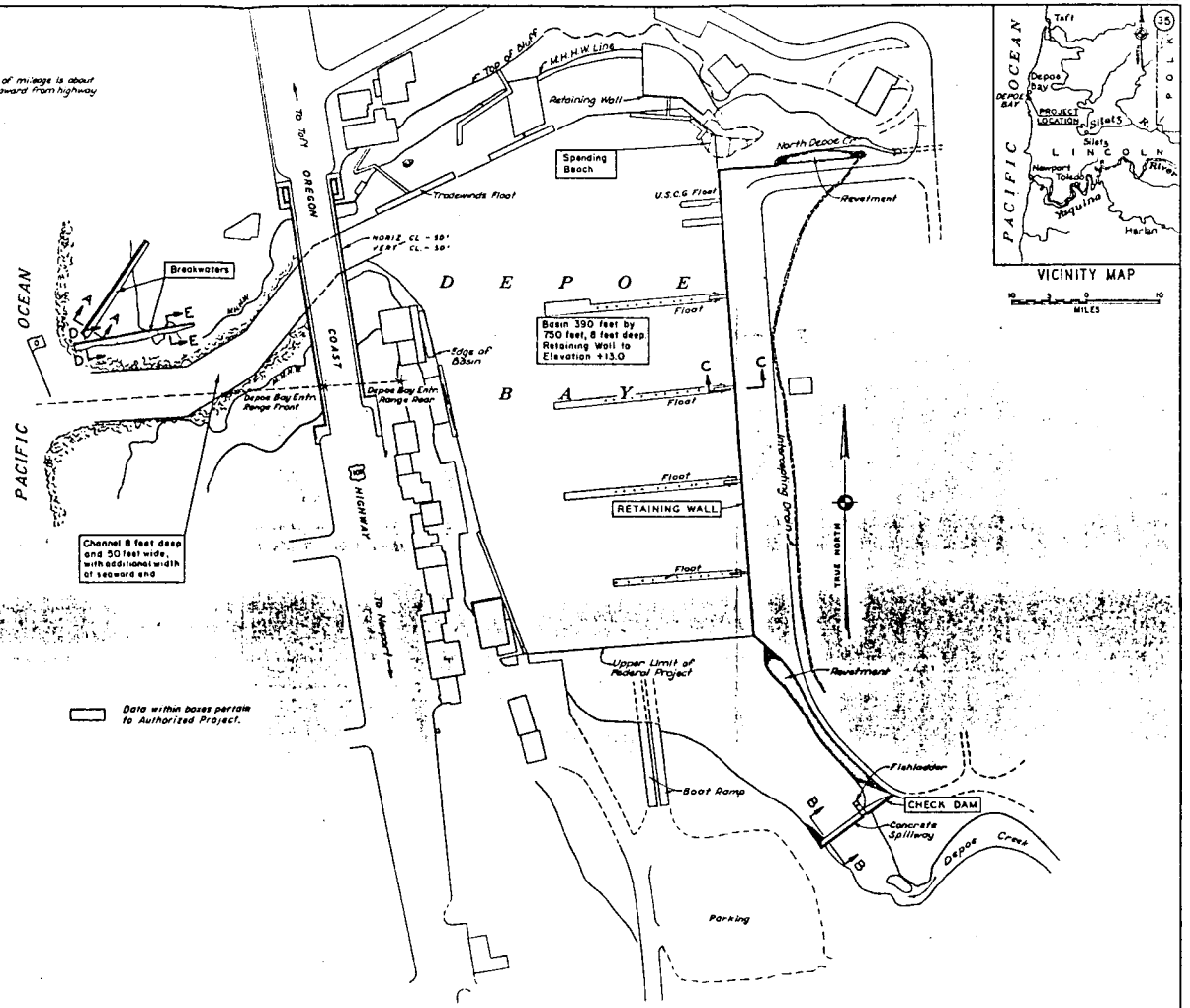


SECTION E-E

BREAKWATER

SCALE IN FEET

Note
Base Point of mileage is about 450 feet seaward from highway bridge



PLAN

SCALE IN FEET

DEPOE BAY, OREGON

SCALES AS SHOWN

U.S. ARMY ENGINEER DISTRICT, PORTLAND

REVISED NOV 1976